"CABLE WITH FIRE-RESISTANT, MOISTURE-RESISTANT COATING"

This application is a continuation of PCT/EP98/01443 filed March 12, 1998 which claims the benefit of United States Provisional Application 60/050,956 filed June 16, 1997, which in turn is based on Italian Application MI97 A-000559 filed March 13, 1997, the contents all of which are incorporated herein by reference.

## Background of The Invention

### Field of the Invention

The present invention relates to an electrical cable, in particular for low-tension power transmission or for telecommunications, this cable comprising a coating which has fire-resistance properties and is capable of keeping its electrical insulation properties unchanged when said cable is in the presence of moisture.

### Description of Related Art

Besides retarding the propagation of fire, cable coatings defined as being "fire resistant" should, in the presence of fire, afford a very low emission of fumes, a low level of emission of noxious gases, and should be self-extinguishing. Combustion-resistant cables are assessed for use in closed environments by means of performance tests against industrial standards which define the limits and provide the methodology for cable flammability tests. Examples of these standards are ASTM 2863 and ASTM E622; IEEE-383, IEEE-1202 (devised by the "Institute of Electrical and Electronics Engineers", New York, USA) ; UL-1581 and UL-44 ("Underwriters Laboratories Inc.", Northbrook, Illinois, USA); CSA C22.2 0.3 ("Canadian Standard Association", Toronto, Canada).

Typical characteristics of moisture-resistant coatings are a limited absorption of water and the maintenance of constant electrical properties, even in the presence of moisture; an example of a reference standard

causing the formation of a whitish compound on the surface of the cable coating.

Neither of these documents mentions the problem of maintaining the dielectric insulation properties after exposure of the cable to a wet environment, nor the problem of strippability mentioned above.

GB 2,294,801 discloses a cable having an inner sheath made of polyethylene (PE) or polypropylene (PP) in contact with the conductive wire and an outer sheath made of fire retardant material, such as"low smoke zero halogen" rubber or PVC. The PE or PP employed as materials for the inner layer are intended as waterproof materials. However, no mention is made about the fire retardant properties of the said inner layer. As a matter of fact, the presence of the inner layer consisting essentially of a polyolefynic material would substantially reduce the overall fire resistance properties of the cable's sheath.

Summary of the Invention

The Applicant has observed that the properties of fire resistance and of insulation resistance in the presence of moisture are difficult to reconcile in a single cable coating, since the fire resistance is increased the larger the amount of inorganic charge present in the coating, whereas the insulation resistance in the presence of moisture reduces as the inorganic charge in the coating increases. The Applicant has also observed that the presence of suitable coupling agents in the mixture which forms the coating, while improving the insulation resistance of the coating, lowers its capacity

presence of moisture; and the outer layer comprises a base polymer matrix and an inorganic charge dispersed in this matrix in an amount such as to provide the cable with the desired fire-resistance properties.

The Applicant has observed that when the coupling agent present in the inner layer is a polyolefin compound containing at least one unsaturation and at least one carboxyl group in the polymer chain (identified in the remainder of the present description by the term "carboxylated polyolefin"), the resulting cable not only has the desired insulation-resistance properties in the presence of moisture but is also readily strippable.

The Applicant has also observed that if a polymer composition for coating cables does not contain such an additive or other coupling agent known in the art, or at any rate contains it in amounts lower than the abovementioned predetermined amount, when said cable is in the presence of moisture this coating is able to absorb a certain amount of water, thereby increasing the fire resistance of this cable.

The Applicant has moreover found that with the abovementioned double-layer structure of the coating, the outer layer being the one which mainly imparts the fire resistance, it is possible to add to this outer layer an amount of inorganic charge which is greater than the amount of the inner layer, without this having a negative impact on the dielectric properties of the coating, [whichare] which are, in any case, guaranteed by the presence

of the

inner layer; in this way, the fire resistance of the outer layer is increased both owing to the larger amount of inorganic charge present and owing to the increased capacity of said inorganic charge to absorb water (that is to say more inorganic charge capable of absorbing water). On the other hand, by endowing the inner layer with substantial fire-resistant properties, thus contributing to the overall fire-resistant properties of the cable, the applicant has found that it is possible to advantageously reduce the thikness of the outer layer of the coating, with respect to the thickness of an outer layer enveloping an inner layer having no fire-resistant properties.

In this respect, the Applicant has also found that an advantageous embodiment of the present invention is obtained by suitably selecting the kind of mineral charge to be added in the two layers, in such a way to further improve the moisture resistance of the cable coating at high temperatures.

## Brief Description of The Drawings

Fig. 1 schematically shows the cross-sectional drawing of a cable according to the invention, comprising a conductor (1, a layer of inner coating (2) and a layer of outer coating (3). The conductor may optionally be coated with a strip of polymer material, typically polyester, in order to facilitate detachment of the coating.

## Detailed Description

A first aspect of the present invention thus relates to an electrical cable which has predetermined fire-resistance and electric insulation-resistance properties

in the presence of moisture, this cable comprising a metal conductor and at least one polymer coating consisting of a double layer, in which the outer layer of this coating is designed so as mainly to impart to the cable said fire-resistance properties, and the inner layer is designed so as to impart to the cable said insulation-resistance properties in the presence of moisture, while

of coupling agent, in order to improve the compatibility between the inorganic charge and the polymer matrix, thereby improving the mechanical properties of the coating; this coupling agent may be a carboxylated polyolefin of the type contained in the inner layer or, more preferably, a silane-based compound of the type known in the art.

In this respect, the Applicant has found that the amount of coupling agent required to ensure the right degree of compatibility between the polymer matrix and the inorganic charge is considerably less than the amount required to keep the electrical properties substantially unchanged when the coating is in the presence of moisture. Hence, the fact that the outer layer contains reduced amounts of coupling agent (typically from 10% to 70% by weight relative to the weight required to keep the electrical properties constant in the presence of moisture) allows this layer, when the cable is in the presence of moisture, to still absorb a certain amount of water, thereby increasing the fire resistance of the coating; the electrical properties of the coating are, in any case, ensured by the presence of the inner layer.

The additive which is capable of exerting the fire-resistance effect according to the invention is generally an inorganic oxide, preferably in hydrated or hydroxide form. Examples of suitable compounds are aluminum oxide, bismuth oxide, cobalt oxide, iron oxide, magnesium oxide, titanium oxide and zinc oxide, their respective hydrated forms, and mixtures thereof, in any ratio, based on the particular requirements.

Preferably, these inorganic charges are used in hydrated form, magnesium hydroxide being particul~~arly~~ preferred, aluminum oxide trihydrate ($Al_2O_3 \cdot 3H_2O$), or mixtures thereof being particularly preferred; limited amounts, generally less than 25% by. weight, of one or more inorganic oxides chosen from Coo, PbO, $TiO_2$, $Sb_2O_3$, ZnO and $Fe_2O_3$, or mixtures thereof, preferably in hydrated form, may advantageously be added to these compounds or mixtures.

According to a particularly preferred embodiment the inner layer comprises as main compound of mineral charge an aluminum oxide, preferably in hydrated form or as hydroxide.

In the present description the term "main compound" of the mineral charge is intended to refer to the mineral charge which contains tipically at least the 75%, preferably the 90% of such compound.

anhydride; it is particularly preferred to use maleic anhydride.

In general, the ratio between the carboxylic groups and the unsaturations in the final compound may vary depending on various factors, such as, for example, the amount and composition of the unsaturated compounds and of the carboxylated compounds which are reacted, the amount of inorganic charge present in the coating, and the like. Usually, this carboxyl groups/unsaturations ratio may range from 1:10 to 1:100, a ratio of between 1:10 and 1:50 being preferred.

When the carboxylated polyolefin is formed by reaction between polybutadiene with a polymerization number of about 100 and maleic anhydride, the amount of maleic anhydride reacted will generally range from 5 to 25% of the weight of polybutadiene, about 10% by weight being preferable.

An example of a commercially available carboxylated polyolefin which is suitable for the purposes of the present invention is Lithene N4 B10 MA (Revertex Ltd.), which is a maleic-treated polybutadiene.

The amount by weight of coupling agent in the inner layer may vary mainly depending on the type of coupling agent used and on the amount of inorganic charge present; the coupling agent will, however, always be added in an amount which affords the desired insulation-resistance, properties in the presence of moisture. The amount of coupling agent in the [outer] <u>inner</u> layer is generally between 1%